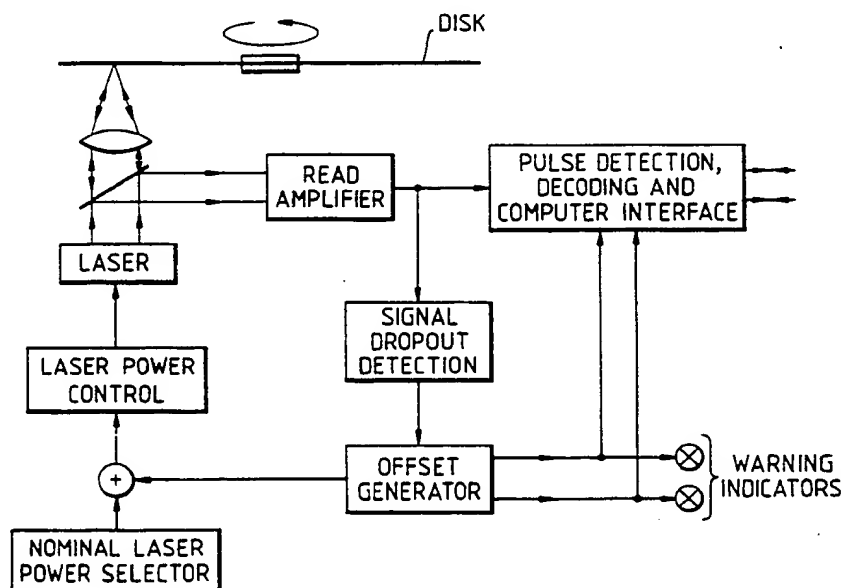




INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(21) International Application Number: PCT/GB91/02186 (22) International Filing Date: 10 December 1991 (10.12.91) (30) Priority data: 9026774.1 10 December 1990 (10.12.90) GB (71) Applicant (for all designated States except US): PLASMON DATA SYSTEMS, INC. [US/US]; 99 West Tasman Drive, San Jose, CA 95134 (US). (72) Inventors; and (75) Inventors/Applicants (for US only) : LONGMAN, Robert, James [GB/GB]; 20 Winchmore Drive, Trumpington, Cambridge CB2 2LW (GB). HELFET, Peter, Roy [GB/GB]; 5 Meadow Drive, Hendon, London NW4 1SD (GB). LISTER, Quentin, Johnathan [GB/GB]; 16 St. Matthew's Street, Cambridge CB1 2LT (GB). BROADBENT, Mark, John [GB/GB]; 2 Capstan Close, Cambridge CB4 1BJ (GB).			(74) Agents: GODSILL, John, Kenneth et al.; Haseltine Lake & Co., Hazlitt House, 28 Southampton Buildings, Chancery Lane, London WC2A 1AT (GB). (81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), JP, LU (European patent), MC (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report.</i>

(54) Title: IMPROVING OPTICAL DISK RECORDING PERFORMANCE



REDUCING THE EFFECT OF OPTICAL PATH ATTENUATION
ON WRITE PERFORMANCE

(57) Abstract

A method and apparatus for improving optical disk recording performance is disclosed, which comprises reading data from an optical disk while writing data to the disk in order to verify the data, to control the power of the recording laser and to prevent overwriting of the disk.

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IMPROVING OPTICAL DISK RECORDING PERFORMANCE

This invention relates to the improvement of optical disk recording performance.

5 During the recording process of writable optical disks, data is written as the disk rotates. To check that the data was written correctly, it is read back from the disk (usually known as verifying the data) on the following revolution. It therefore takes two revolutions
10 of the disk to successfully write and verify data.

We have found that the time to write and verify data can be halved by reading the data from the disk while writing it (Direct Read During Write, DRDW).

Write Once optical disks (WORM disks) made by
15 Plasmon Data Systems use a 'moth eye' texture as the recording medium (see, for example, U.S. Patents 4,616,237; 4,786,585; 4,724,444; and 4,758,307). Marks written by the laser form very quickly (typically 5-20ns). Mark formation can be detected by monitoring the
20 read photodiode during writing (see Figure 1).

Accordingly, one aspect of the present invention provides a method for improving optical disk recording performance which comprises reading data from an optical disk while writing data to said disk.

25 If every bit of data is written successfully there will be no errors when reading the data. Indeed, the read channel error correction can cope with several bits in error before reporting a verify failure.

In one embodiment of this invention, there is
30 provided a pulse detector capable of detecting marks forming on the disk surface during write. If the normal mark formation is not seen, it is a bad mark, or bit in error. By simply counting the number of bad marks during writing, data which will pass the verify read can be
35 positively identified by observing a low count (of the order of a few bits) on the bad pulse counter.

In cases of few bits in error being detected, no

verification is required.

If more than a few bad marks are detected, the normal verify sequence is triggered. This will test whether the error correction can cope with the number of bits in error.

Figure 2 shows the distribution of numbers of bits in error in sectors on a typical Plasmon disk. Most sectors have no bits in error, and so a high hit rate of zero counts can be expected (approximately 99.3%). If two bits in error are taken as acceptable, the hit rate would be 99.8%. The time to perform most writes should therefore be halved.

Recording marks on optical disks requires accurate control of laser power. A small percentage change in the write power will cause a dramatic difference in the written mark size.

Accordingly, in a second embodiment of the present invention, there is provided laser power control using feedback photodiodes within the laser module to provide the desired laser power. Outside of the laser module, optical elements direct the light to and from the disk surface.

In normal operation the optical elements get dirty with airborne dust, smoke particles etc. Each dirty surface reduces the laser power by a (small) percentage. The optical disk surface can also get dirty causing further signal loss.

There is a greater latitude in laser power during reading due to careful circuit design, while accurate write laser power is demanded by the physical properties of the disk. Writing data will become unreliable long before reading is impaired.

In practice, Plasmon have found the problem may cause poor disk drive performance (many write-retry attempts), with possible loss of data.

By monitoring the mark formation during writing (see Method 1 of improving drive performance), poorly formed, and low amplitude marks can be detected. It is possible to use the written mark amplitude to adjust the laser power up or down as necessary. By careful use of time constants in the control circuit, disk defects should not cause sudden glitches in the write power (see Figure 3).

When the drive control attempts to increase the laser power more than a given percentage, the user can be warned that the optical elements, or disk are in need of cleaning.

A second level of warning can be set when the maximum laser power has been reached, informing the user that the write performance has been impaired due to an obscured optical path.

Write once optical disks (WORMs) cannot be erased. However, if data is written in a given sector, and the drive is requested to write the same sector again, the original data is corrupted, and lost forever. In normal operation, host computer software will prevent the overwriting of existing data.

However, in cases of software bugs, or other errors, an erroneous write could prove disastrous.

Checking that a sector is blank by reading it before writing it is unacceptably slow involving an extra disk revolution before each write operation.

According to a third embodiment of the present invention, marks are monitored as they are being formed on the disk surface. Mark formation is very rapid on the 'moth eye' surface (typically 5-20ns). Figure 4 shows marks being formed on Plasmon media. If the area of the disk is already written, the mark formation signal looks different (see Figure 5).

By analysing the mark formation signal, and the differential of the mark formation signal, it is possible to distinguish between normal and overwrite conditions.

Using this method, it is only possible to detect when writing over an already written pulse. The read channel must therefore be observed between each write pulse for the presence of already written bits. By
5 using a carefully chosen start up signal, it is possible to detect overwriting in all situations (see Figure 6), before any user data is written.

It is therefore possible to prevent overwriting in hardware at the lowest possible level.

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CLAIMS

1. A method of improving optical disk recording
5 performance which comprises reading data from an optical
disk while writing data to said disk.

2. A method according to claim 1, wherein data
written to said disk is read and verified immediately
after being written, and wherein said data is in the form
10 of marks formed in the disk by a laser beam.

3. A method according to claim 2, wherein said
data is read by monitoring the formation of said marks
with a read photodiode during writing.

4. A method according to claim 3, wherein said
15 read photodiode is connected to a pulse detector, which
pulse detector is capable of detecting said marks forming
in said disk during writing.

5. A method according to claim 4, wherein said
pulse detector is arranged so as to count the number of
20 abnormal marks formed.

6. A method according to claim 5, wherein a
verifying sequence is triggered if more than a pre-
determined number of abnormally formed marks are
detected.

7. A method according to claim 4, wherein said
25 pulse detector is arranged so as to measure the amplitude
of said marks formed.

8. A method according to claim 7, wherein the
power of the writing laser is controlled as a function of
30 the amplitude of said marks.

9. A method according to claim 8, wherein an
indication is given when the power of said laser is
higher than, or at, a pre-determined level.

10. A method according to claim 4, wherein said
35 pulse detector is arranged so as to detect whether the
area of said disk being written to has already been
written to.

11. A method according to claim 10, wherein said pulse detector is arranged so as to detect whether the area about to be written to has already been written to.

12. A method according to claims 10 or 11, wherein
5 overwriting of the disk is minimised.

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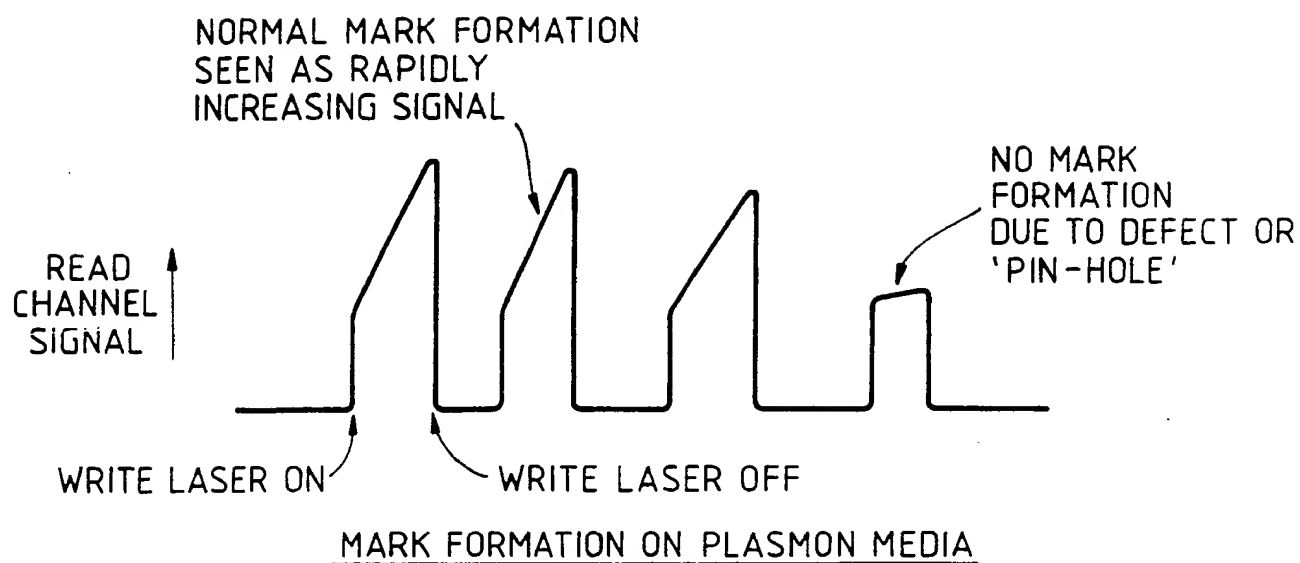
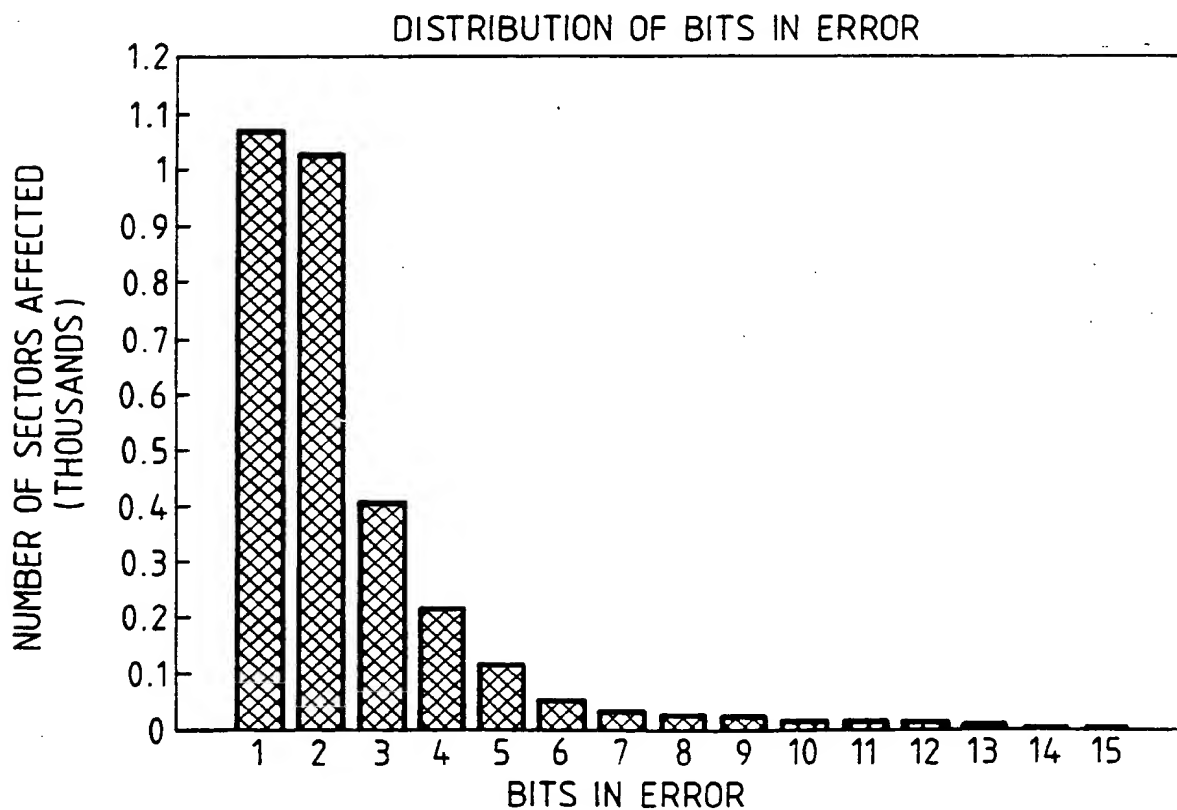
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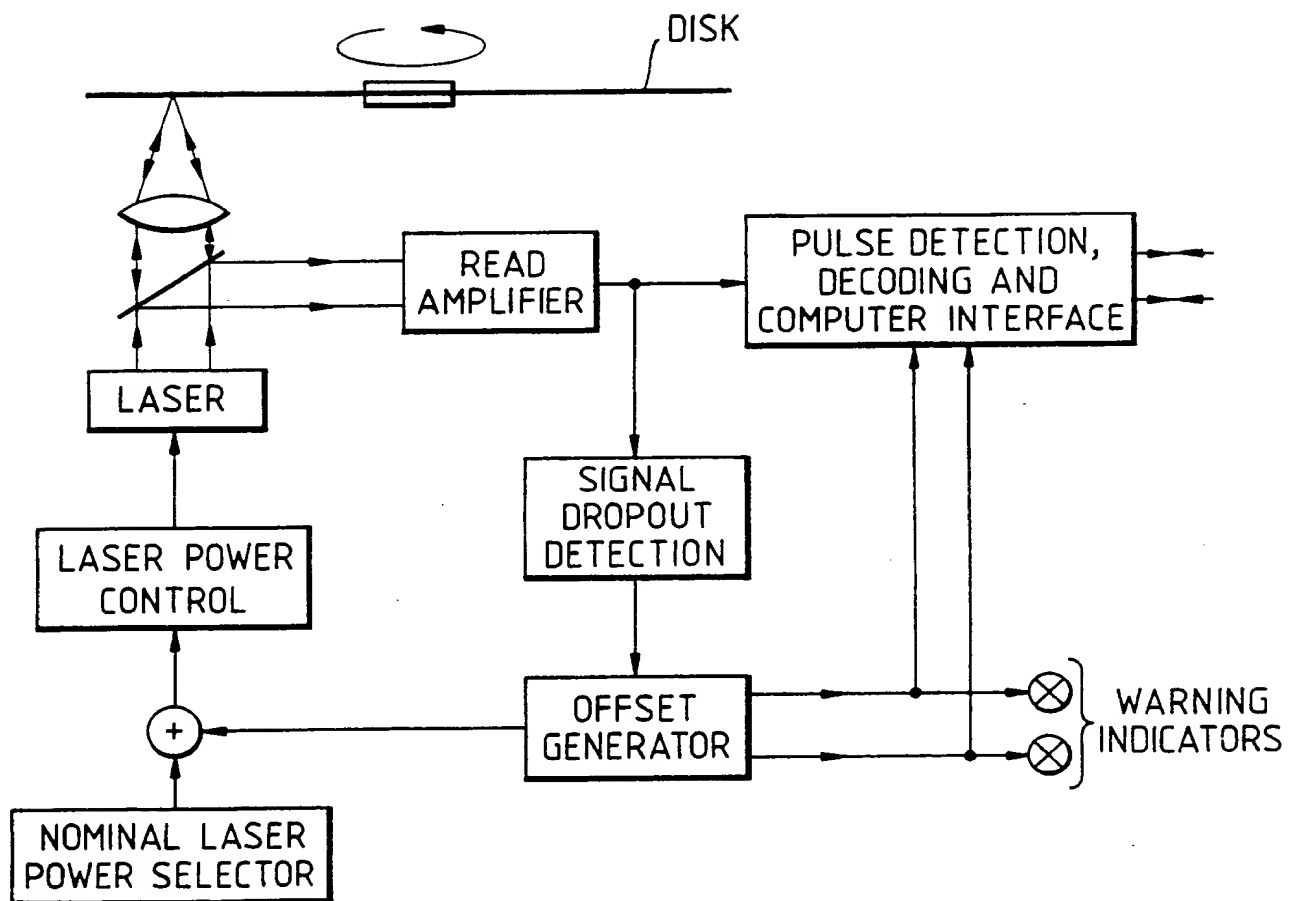
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Fig. 1.*Fig. 2.*

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Fig. 3.



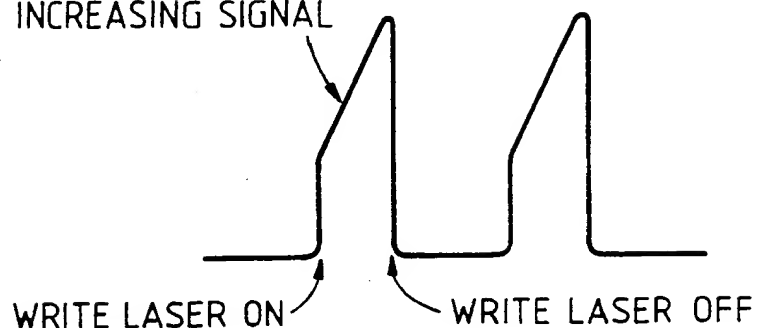
REDUCING THE EFFECT OF OPTICAL PATH ATTENUATION
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SUBSTITUTE SHEET

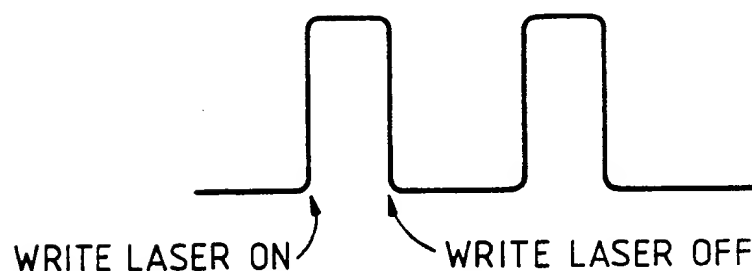
3/3

Fig. 4.

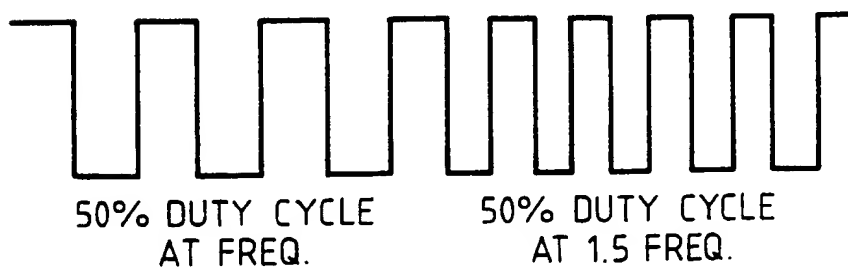
NORMAL MARK FORMATION
SEEN AS RAPIDLY
INCREASING SIGNAL



NORMAL MARK FORMATION ON PLASMON MEDIA

Fig. 5.

OVERWRITE OCCURRING ON PLASMON MEDIA

Fig. 6.

START UP SIGNAL TO DETECT OVERWRITING

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/02186

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC5: G 11 B 7/00														
II. FIELDS SEARCHED <div style="text-align: right; margin-right: 100px;">Minimum Documentation Searched⁷</div> <table style="width: 100%; border: none;"> <tr> <td style="width: 25%; border: none;">Classification System</td> <td style="border: none;">Classification Symbols</td> </tr> <tr> <td style="border: 1px solid black; height: 40px; vertical-align: bottom;">IPC5</td> <td style="border: 1px solid black; height: 40px; vertical-align: bottom;">G 11 B</td> </tr> </table> <div style="text-align: center; margin-top: 10px;">Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in Fields Searched⁸</div>			Classification System	Classification Symbols	IPC5	G 11 B								
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IPC5	G 11 B													
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">Category *</th> <th style="width: 60%;">Citation of Document,¹¹ with indication, where appropriate, of the relevant passages¹²</th> <th style="width: 30%;">Relevant to Claim No.¹³</th> </tr> </thead> <tbody> <tr> <td style="text-align: center; vertical-align: top;">X</td> <td>US, A, 4680594 (R. R. BRACHT) 14 July 1987, see the whole document <div style="text-align: center;">--</div></td> <td style="text-align: center; vertical-align: top;">1-6</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X Y</td> <td>US, A, 4648085 (S. SHIMONOU) 3 March 1987, see column 7, line 3 - column 9, line 5 <div style="text-align: center;">--</div></td> <td style="text-align: center; vertical-align: top;">1-3 4,7</td> </tr> <tr> <td style="text-align: center; vertical-align: top;">X Y</td> <td>EP, A2, 0182127 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 28 May 1986, see page 2, line 35 - page 3, line 24; claims 1,2 <div style="text-align: center;">--</div></td> <td style="text-align: center; vertical-align: top;">1,2 3,4,7, 10</td> </tr> </tbody> </table> <div style="font-size: small; margin-top: 10px;"> <div style="display: flex; justify-content: space-between;"> <div style="width: 48%;"> <p>* Special categories of cited documents:¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 48%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance, the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> </div> </div> </div>			Category *	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	X	US, A, 4680594 (R. R. BRACHT) 14 July 1987, see the whole document <div style="text-align: center;">--</div>	1-6	X Y	US, A, 4648085 (S. SHIMONOU) 3 March 1987, see column 7, line 3 - column 9, line 5 <div style="text-align: center;">--</div>	1-3 4,7	X Y	EP, A2, 0182127 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 28 May 1986, see page 2, line 35 - page 3, line 24; claims 1,2 <div style="text-align: center;">--</div>	1,2 3,4,7, 10
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X Y	EP, A2, 0182127 (INTERNATIONAL BUSINESS MACHINES CORPORATION) 28 May 1986, see page 2, line 35 - page 3, line 24; claims 1,2 <div style="text-align: center;">--</div>	1,2 3,4,7, 10												
IV. CERTIFICATION <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Date of the Actual Completion of the International Search</td> <td style="width: 50%; border: none;">Date of Mailing of this International Search Report</td> </tr> <tr> <td style="border: 1px solid black; height: 40px; vertical-align: bottom;">27th February 1992</td> <td style="border: 1px solid black; height: 40px; vertical-align: bottom; text-align: center;">11. 03. 92</td> </tr> <tr> <td style="border: none;">International Searching Authority</td> <td style="border: none;">Signature of Authorized Officer</td> </tr> <tr> <td style="border: 1px solid black; height: 40px; vertical-align: bottom; text-align: center;">EUROPEAN PATENT OFFICE</td> <td style="border: 1px solid black; height: 40px; vertical-align: bottom; text-align: center;">Nicole De Bie </td> </tr> </table>			Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	27th February 1992	11. 03. 92	International Searching Authority	Signature of Authorized Officer	EUROPEAN PATENT OFFICE	Nicole De Bie				
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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No
Y	US, A, 4606016 (J. J. VERBOOM ET AL) 12 August 1986, see column 4, line 23 - column 5, line 36 --	1-4,7, 10
P,X	EP, A2, 0420252 (KABUSHIKI KAISHA TOSHIBA) 3 April 1991, see column 9, line 42 - column 11, line 4; column 13, line 42 - column 17, line 6 -- -----	1-4,10- 12 5-9
P,A		

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4680594	14/07/87	NONE	
US-A- 4648085	03/03/87	JP-A- 59207435 JP-A- 59207436	24/11/84 24/11/84
EP-A2- 0182127	28/05/86	JP-A- 61126643 US-A- 4631706	14/06/86 23/12/86
US-A- 4606016	12/08/86	AU-B- 575901 AU-B- 592706 AU-B- 592707 AU-D- 1819688 AU-D- 1819788 AU-D- 3796485 CA-A- 1231777 EP-A-B- 0154389	11/08/88 18/01/90 18/01/90 15/09/88 15/09/88 15/08/85 19/01/88 11/09/85
EP-A2- 0420252	03/04/91	JP-A- 3116534	17/05/91

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